LAKE TAHOE WATERSHED MODEL PARAMETER ESTIMATES

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R&D Program

PURPOSE

- DEVELOP A PRACTICAL DESIGN STORM METHOD FOR ESTIMATING DESIGN DISCHARGE APPLICABLE TO LOW ELEVATION WATERSHED OPEN AREAS
- METHOD NEED TO ACCOUNT FOR SNOW AFFECTED RUNOFF IMPORTANT TO LAKE TAHOE HYDROLOGY
- ADDRESS “FROZEN GROUND” SNOW COVERED AREA LOSS RATE ISSUE

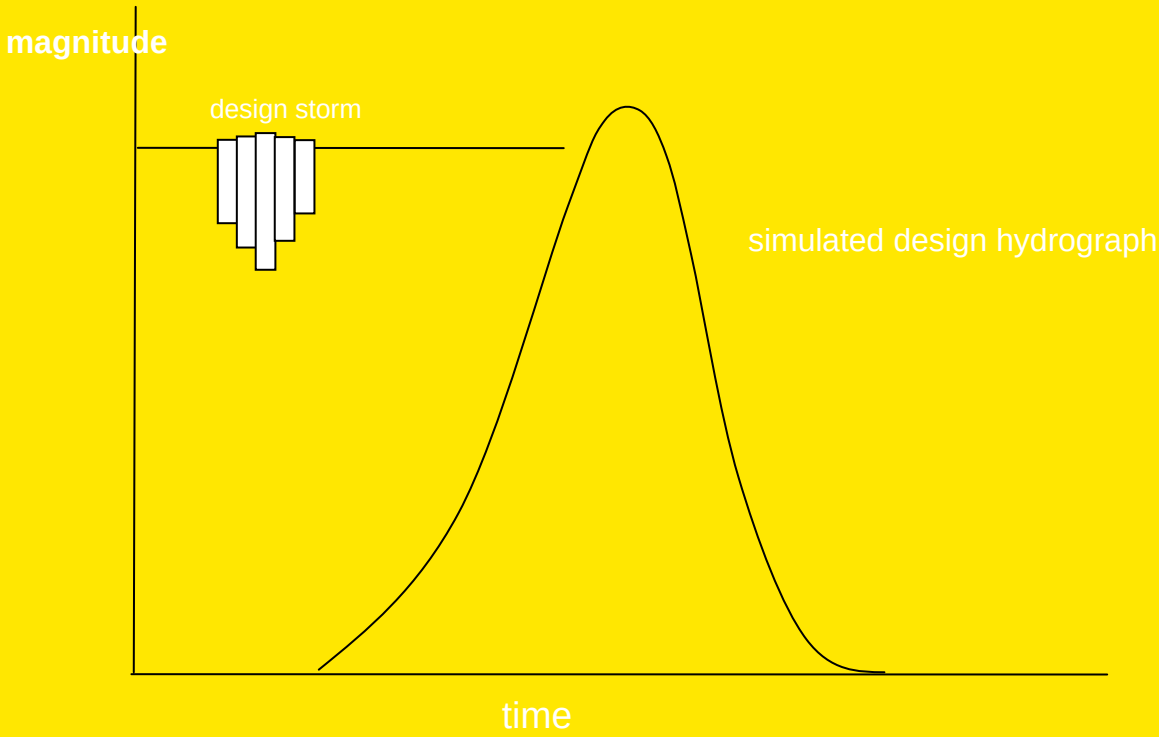
Purpose

- Estimate Loss rates/runoff coefficients for Lake Tahoe Watersheds
  - Application with modified version of HEC-1
  - Focus on areas below 6700 ft
- Provide recommendations for guidance in county drainage design manual
  - Application should be practical (useful with commonly available models)
  - Simple approximation for snowmelt contribution

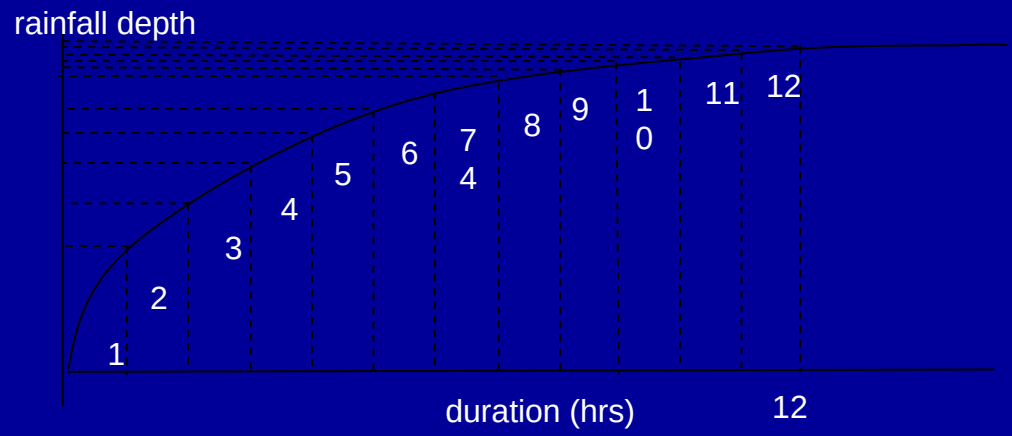
Why Elevations < 6700 ft?

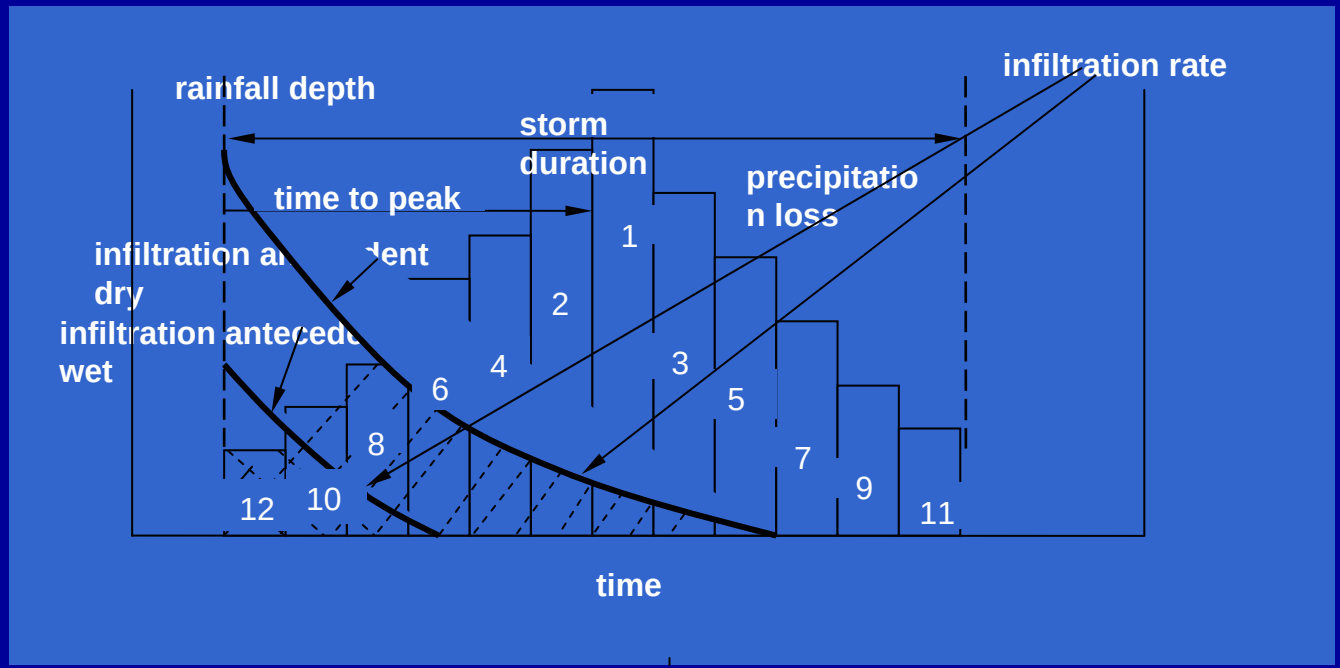
- REGIONAL REGRESSION EQUATIONS DERIVED FROM WATERSHEDS WITH MEAN ELEVATION MUCH GREATER THAN 6700 FT
- REGRESSION EQUATIONS FOCUS ON NATURAL (OPEN) AREAS
- URBAN HYDROLOGY APPLICATIONS IMPORTANT

Event Watershed Model



HEC-1 Balanced Design Storm





Modeling Goal

- EFFECTIVE LOSS RATES/RUNOFF COEFFICIENTS TO BE USED WITH DESIGN STORMS
  - ACCOUNT FOR ANTECEDENT CONDITIONS/LOSS RATES/MELT
  - DEPENDS ON PRECIPITATION PHASE, SNOW PACK CONDITION, MELT RATE, LOSS RATES

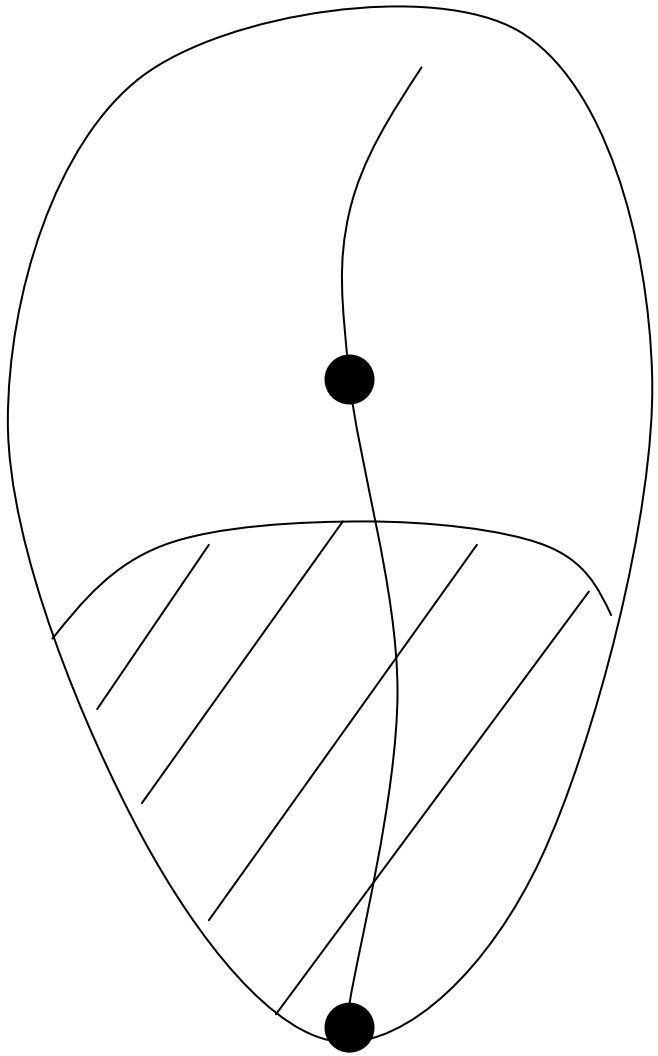
Modeling Approach

- Calibrate HEC-1 to major observed events
  - Determine melt rate coefficients, lapse rate, routing lags, loss rate/runoff coefficients
- Use major observed events as templates for calibrating models to flow-frequency estimates obtained from gage records
  - Ratio storm patterns to have same 24 hour depth as from NOAA14
  - Adjust loss rates/runoff coefficients to reproduce frequency curves (e.g., 100 year flow) at gage or using regression equations

Model for Areas below 6700 ft

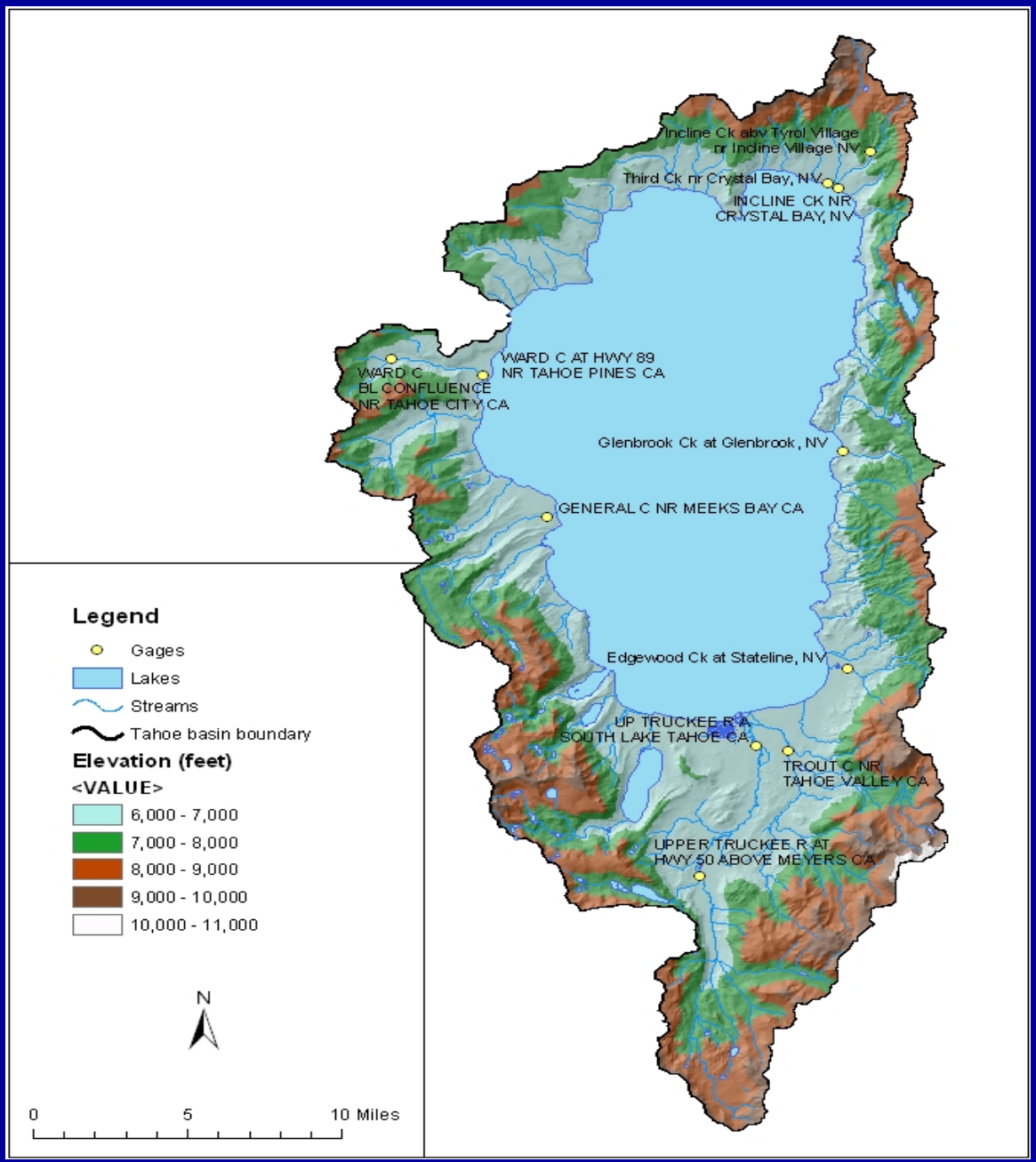
- Determine flow-frequency for drainage areas below 6700 ft from application of template events (e.g., estimate 100 year flow)
  - Discharge obtained from lowest sub-area
  - Reproduce flow frequency from gage or regression estimate
- Calibrate HEC-1 balanced design storm (NOAA14 design storm) to reproduce flow (e.g., 100 year 24hr design storm to produce 100 year peak flow) estimated for sub-area
  - Key parameter is effective loss rate/runoff coefficient

Watershed below 6700 feet



Why Template Events?

- Captures a realistic coincidence of meteorologic and hydrologic conditions that affect runoff in the Lake Tahoe Basin
  - Precipitation pattern
  - Temperature Lapse rate
  - Snow pack conditioning and water equivalent
  - Corps Engineers uses template event in SPF, PMF and recently in estimating inflow frequency to Folsom Dam


Incline Ck abv Tyrol Village nr Incline Village NV
Third Ck nr Crystal Bay, NV
INCLINE CK NR CRYSTAL BAY, NV
WARD C AT HWY 89 NR TAHOE PINES CA
WARD C BL CONFLUENCE NR TAHOE CITY CA
Glenbrook Ck at Glenbrook, NV
GENERAL C NR MEEKS BAY CA
Edgewood Ck at Stateline, NV
UP TRUCKEE R A SOUTH LAKE TAHOE CA
TROUT C NR TAHOE VALLEY CA
UPPER TRUCKEE R AT HWY 50 ABOVE MEYERS CA
Legend
Gages
Lakes
Streams
Tahoe basin boundary
Elevation (feet)
<VALUE>
6,000 - 7,000
7,000 - 8,000
8,000 - 9,000
9,000 - 10,000
10,000 - 11,000
N
0
5
10 Miles

Hec-1 Model Formulation

- Sub-basins based on 500 foot elevation zones
- Methods
  - Degree day melt rate coefficient
  - Lapse rate/500 feet
  - Initial/Constant loss rate (Runoff Coefficient)
  - Constant Base flow
  - SCS lag UH
  - Muskingum Routing

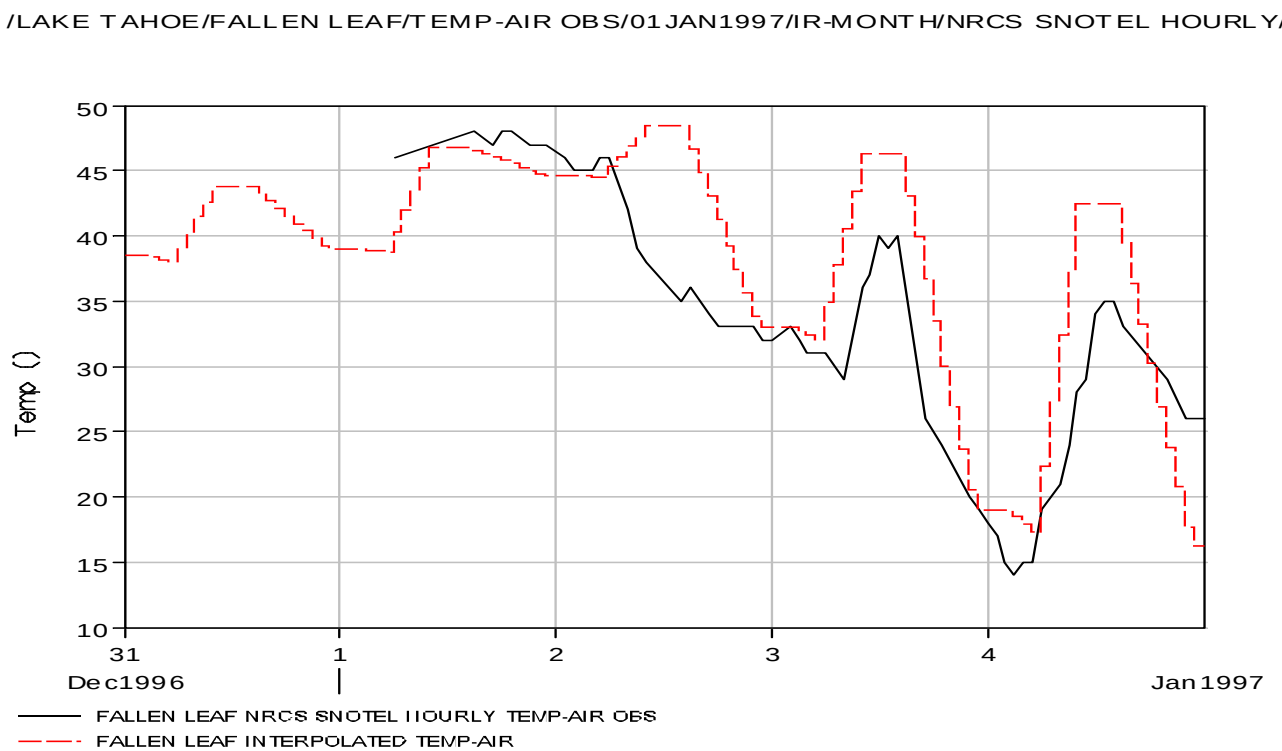
Modifications to HEC-1 Snowmelt Algorithm

- Need to capture the snow pack condition in modeling observed events
  - Analysis of snow pillow data indicated the variation in snow pack condition with elevation
  - Presumably at higher elevations rainfall can re-freeze/ripen in the pack at the beginning of event
- Altered infiltration algorithm to allow for an initial snow pack loss due to ripening

Lessons from Calibration

- It is about the Precipitation and Snow
- Precipitation always important
- Temperature lapse rate critical
  - Daily max-min temperature not valuable
  - Hourly data needed
- Results very sensitive to snow condition and estimated melt rates from snow-pillow data

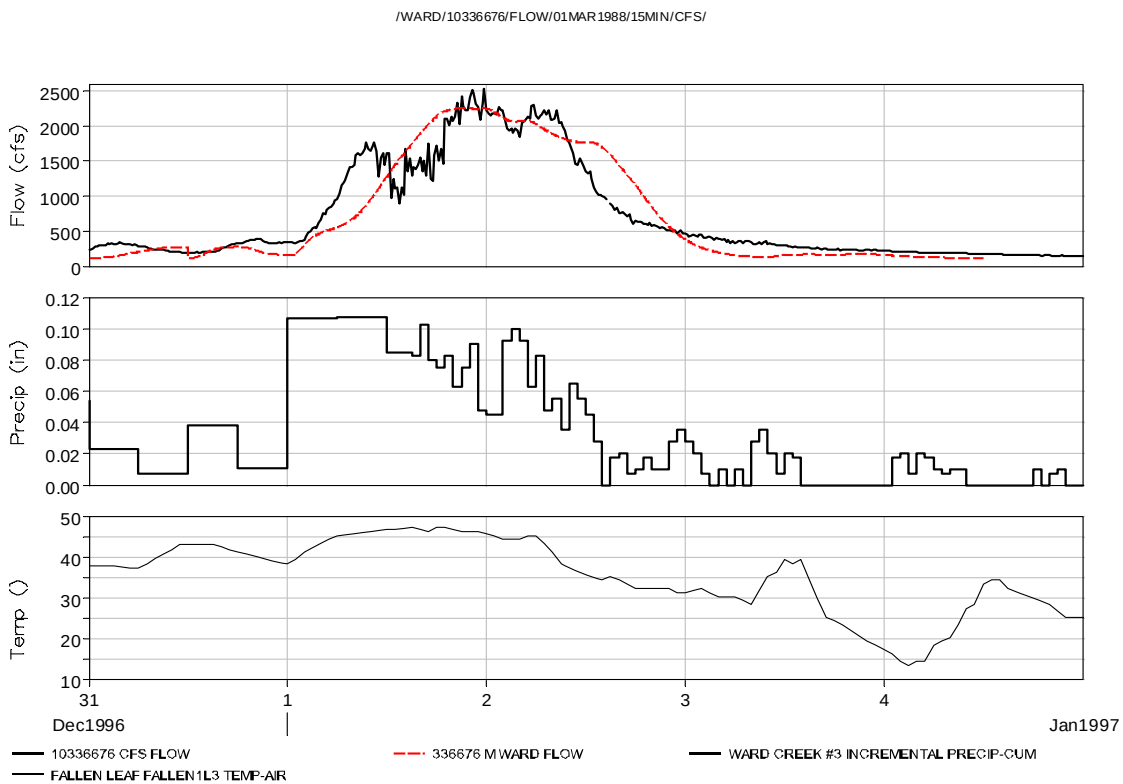
Daily Max-Min vs Hourly Temperature



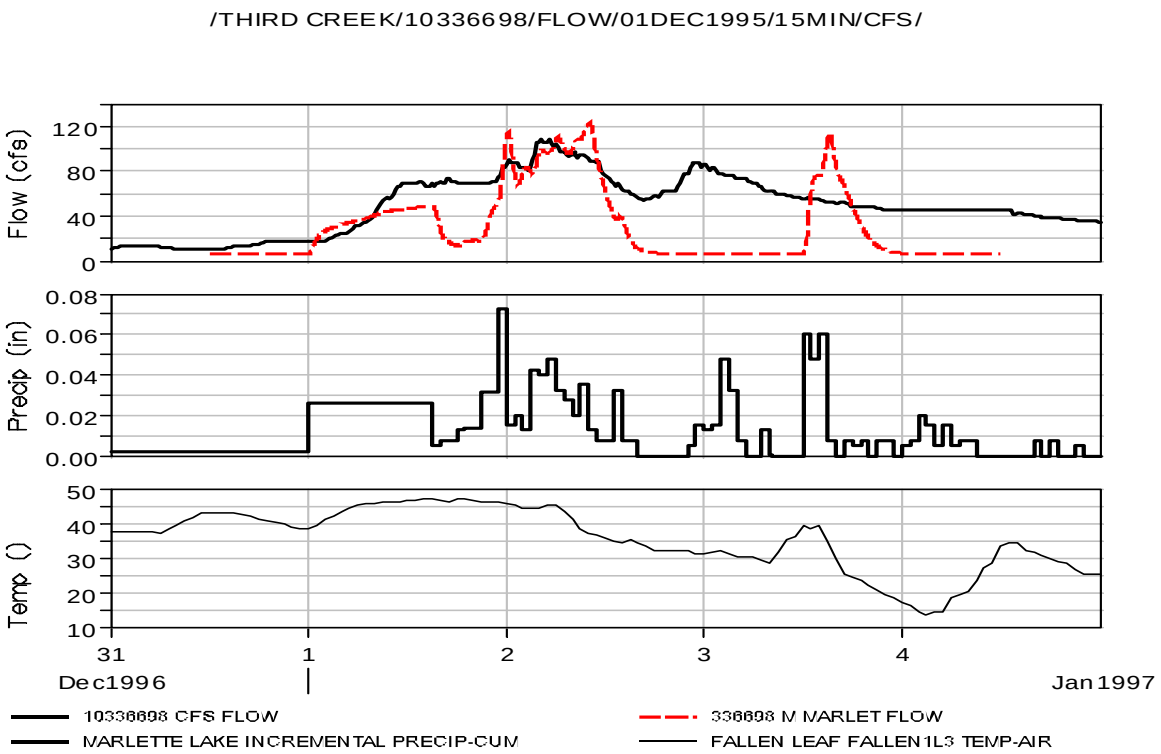
Calibration Events

- 01 January 1997 Event of Record
  - Major Event in California
  - On the order of 100year event
- 24 March 1998 Event
  - On the order of 2 year event
  - Important because it involves precipitation and snow below 6700 feet
  - Typically 2yr event is snowmelt only above 6700 feet

Good Calibration Result, 1997 Ward Creek



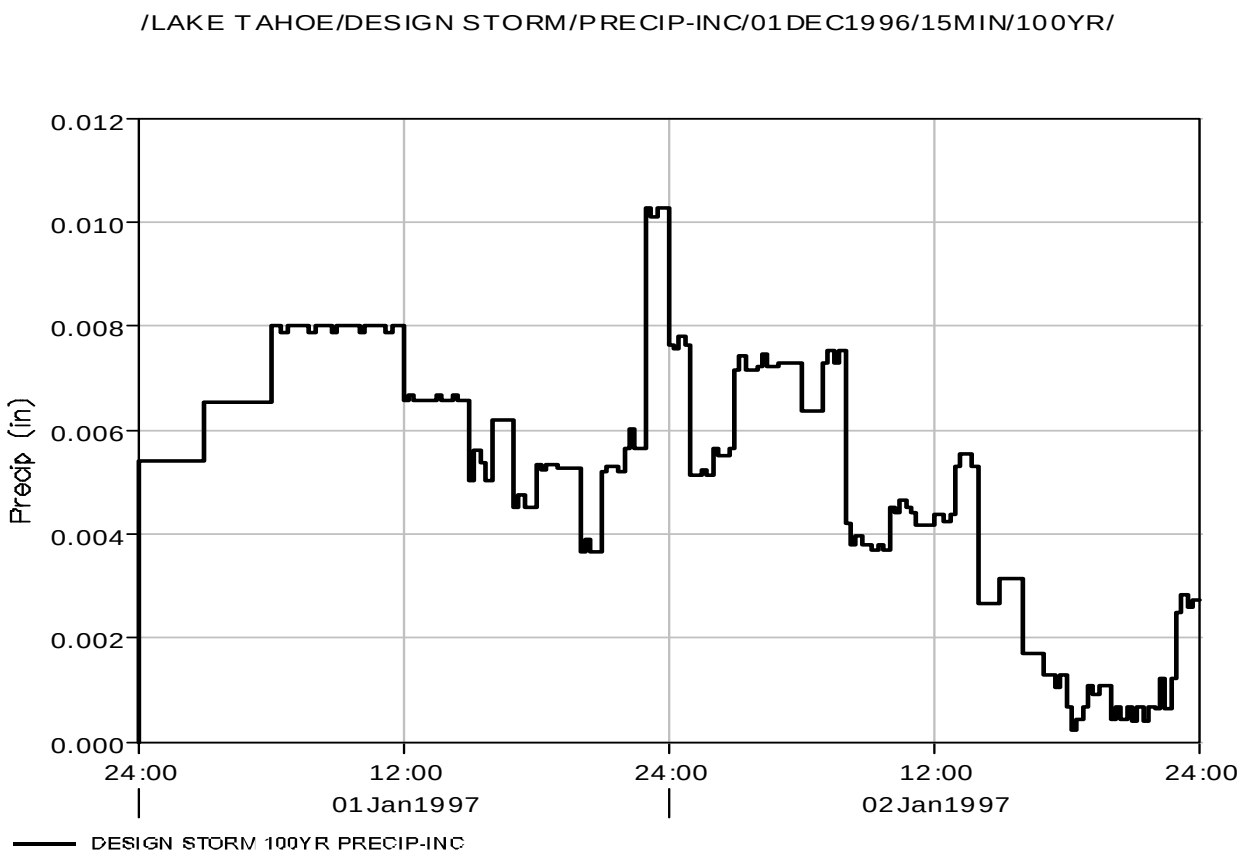
Poor Calibration, 1997 Third Creek



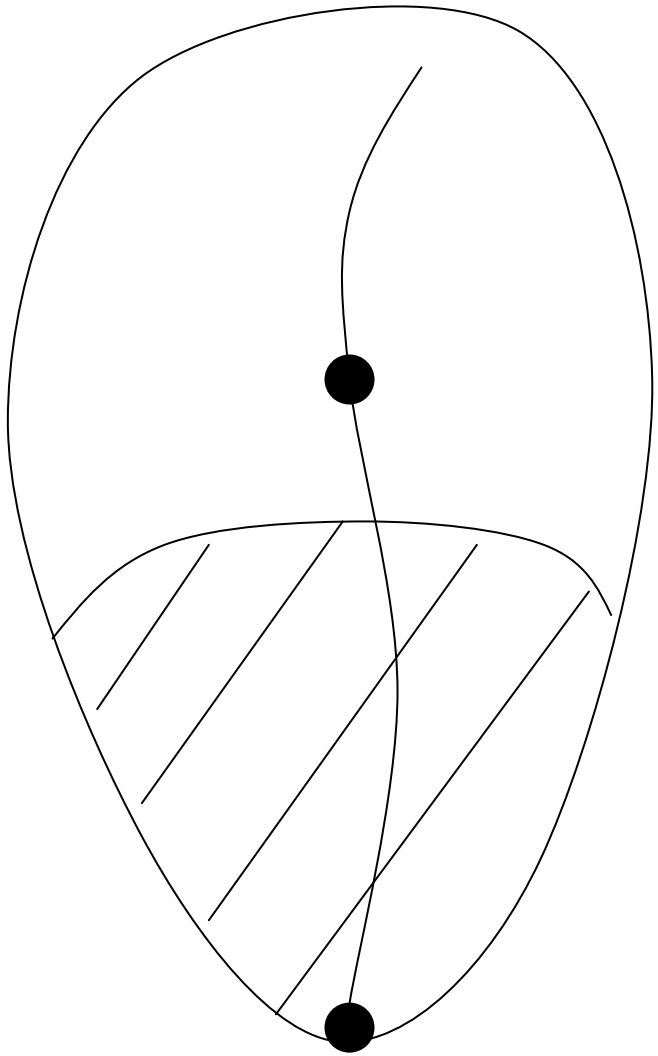
Loss Rates for Areas below 6700 ft

- Design flows for area below 6700 ft determined from application of template events (simulate 100 year precipitation to match 100 year flow)
- Calibrate HEC-1 loss rates to these flows using balanced storm and NOAA14 DDF relationships
  - No snowmelt considered, used effective loss rate as surrogate runoff coefficient

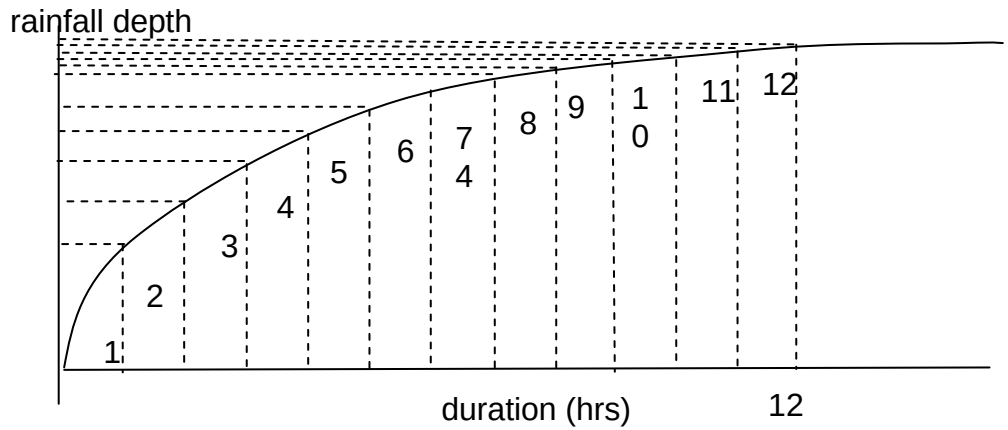
Dimensionless Template Events for 100yr Simulation

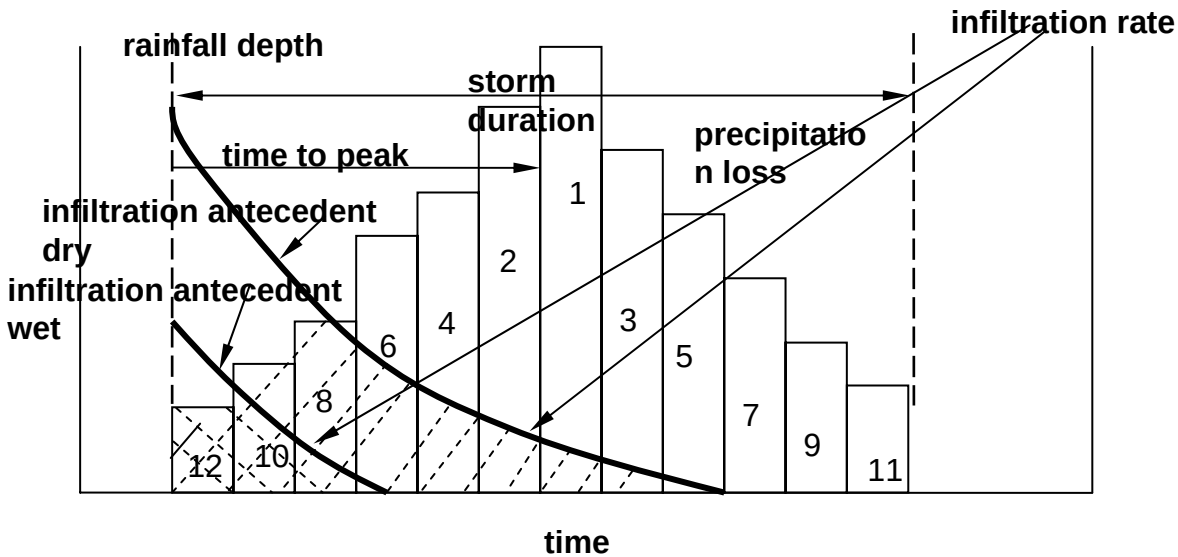


Estimate 100yr Flow Below 6700ft



HEC-1 Balanced Design Storm





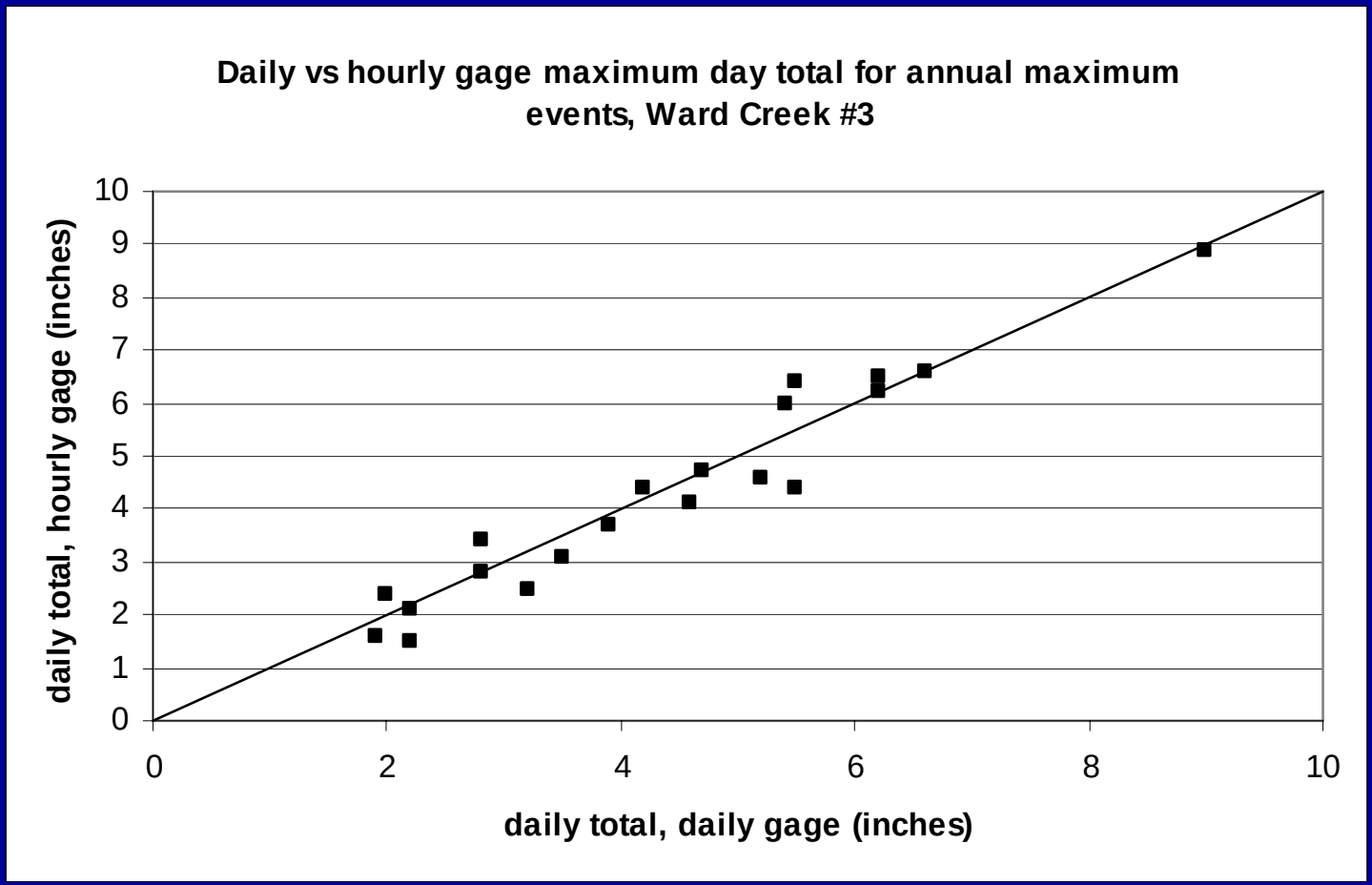
Calibration Loss Rates for HEC-1, NOAA14 balanced storm (5 minute interval) Drainage Area below 6700 ft

Watershed	100 year	2 year
Upper Truckee	0.2	0.1
General	0.2	0.1
Ward	0.05	0.1
Incline	0.3	0.1
Third	0.3	0.1
Glenbrook	0.3	0.1
Trout	0.3	0.1

Application to urban areas

- 100 year discharge, 01 January 1997 template and associated loss rates appropriate
- 2year – 10year?
  - Summer vs winter scenario?
  - Are high intensity short duration summer events important?
  - If so, what are associated open area loss rates?

NOAA14 ISSUES



COMPARISON OBSERVED VS NOAA14 1HR/24HR RATIOS (annual maximums), Ward Creek Gage

water year	1hr	24hr	ratio
1980	0.32	6.54	0.05
1981	0.23	3.15	0.07
1982	0.38	6.48	0.06
1983	0.22	5.21	0.04
1984	0.23	5.50	0.04
1985	0.23	3.37	0.07
1986	0.46	10.41	0.04
1987	0.13	3.19	0.04
1988	0.09	1.90	0.05
1989	0.30	5.50	0.05
1990	0.18	3.51	0.05
1991	0.20	4.74	0.04
1992	0.21	2.78	0.08
1993	0.18	3.93	0.05
1994	0.14	1.62	0.09
1995	0.39	6.23	0.06
1996	0.46	8.22	0.06
1997	**2.12**	**8.94**	**0.24**

return interval	average	min	max
2	0.16	0.20	0.12
10	0.17	0.22	0.13
100	0.22	0.28	0.17

Precipitation Observations

- Period of record (1978-2000) analysis of Ward Creek gage did not show any significant summer thunderstorm events
- Only hourly data available, no shorter duration data
- NRCS SNOTEL data difficult to work with (transmitted data drift, oscillations)

NOAA14 Data Example